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IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

Applicant	: Shunpei Yamazaki, et al.	Art Unit	: 2823
Serial No.	: 08/994,038	Examiner	: W. David Coleman
Filed	: December 18, 1997		
Title	: CHARGE TRANSFER SEMICONDUCTOR DEVICE AND MANUFACTURING METHOD THEREOF		

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P.O. Box 1450
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BRIEF ON APPEAL

(1) Real Party in Interest

Semiconductor Energy Laboratory Co., Ltd. is the real party in interest.

(2) Related Appeals and Interferences

There are no related appeals or interferences.

(3) Status of Claims

Claims 2, 6, 7-10, 11, 12, and 14-26 are pending. Of these, claims 2, 6, 11, 12, 14, and 16-26 have been examined, of which claims 2, 16, 19, 24, 25, and 26 are independent. Claims 1, 3-5, and 13 were previously canceled, and claims 7-10 and 15 are withdrawn.

(4) Status of Amendments

The claims have not been amended subsequent to the final rejection.

(5) Summary of Claimed Subject Matter

The claimed subject matter relates to a semiconductor device including a "charge coupled device" (CCD), in which, for example, light that is incident on a plurality of photo-electric conversion elements (e.g., photo-diodes) is converted into a spatial charge distribution, which is then converted into an output, time-varying signal(s). Such a CCD may be used, for example, as an image sensor, a filter, a memory, or in other contexts. See, e.g., Applicant's specification at page 1, lines 8-19.

Applicant's specification describes structures of a CCD that include a crystalline silicon film having rod-like or columnar crystal bodies extending in a particular direction that coincides, or approximately coincides, with a charge transfer direction of the CCD. In the described structures, crystal grain boundaries extend in the particular direction of the rod-like or columnar crystal bodies, and restrict a movement direction of charge carriers. Further, the crystal structure is continuous in the direction in which the crystal bodies extend, so that this direction may be regarded as a single crystal for the (moving) charge carriers. A result of having the charge transfer direction coincide with the direction in which the crystal bodies (i.e., grain boundaries) extend is that a transfer efficiency of the CCD is increased. See, e.g., Applicant' specification at page 3, lines 3-24. See also, e.g., FIG. 3C of Applicant's specification, illustrating an anisotropic crystal structure 22 having a characteristic direction 27 that is parallel to an underlying substrate 21, and FIGS. 5 and 6, illustrating transmission electron microscope (TEM) photographs of the crystal bodies/structure described above.

These described features are clearly recited in Applicant's claims. For example, independent claim 2 recites, "a crystalline semiconductor film having a plurality of crystals extending in a crystal growth direction, wherein a crystal structure of the crystalline semiconductor film in the crystal growth direction is continuous so that a charge moving is not restricted by a grain boundary, wherein at least one of the vertical and horizontal charge coupled devices that has the crystalline semiconductor film is arranged such that a charge transfer direction of the at least one of the vertical and horizontal charge coupled devices is coincident with the crystal growth direction."

As another example, independent claim 16 recites, "a crystalline semiconductor film formed on an insulating surface, said crystalline semiconductor film having a plurality of crystals extending in a crystal growth direction which is parallel to the insulating surface ... wherein a crystal structure of the crystalline semiconductor film is continuous so that the crystal structure is regarded as single crystal for the charge, wherein the charge transfer direction is coincident with said crystal growth direction." Independent claims 19 and 24-26 recite at least the same or similar features as those just discussed with respect to independent claims 2 and 16.

(6) Grounds of Rejection and Summary of References

Claims 2, 6, 11, 12, 14 and 16-26 are rejected under 35 U.S.C. 103(a) as being unpatentable over U.S. Patent No. 5,873,003 to Inoue et al. (Inoue) in view of U.S. Patent No. 5,582,640 to Okada et al. (Okada).

Inoue discloses a display unit, such as a liquid crystal display unit (LCD), having a plurality of photoelectric converters (e.g., image detectors), for the purpose of, for example, providing a view finder of an electronic camera having a sight-line detection feature (see, e.g., column 5, lines 1-23). Inoue discloses that the photoelectric converters may include, in some embodiments, a CCD (see, e.g., column 16, lines 39-54).

Okada discloses techniques for forming a crystal/polycrystal having a high crystal quality for use in semiconductor devices (see, e.g., Abstract). Okada discloses various semiconductor devices, other than CCDs, that may be manufactured according to such techniques (see, e.g., FIGS. 54-60, 75A, 75B, 76, 77, 81A-81K, 82, and 87-89).

(7) Issues

Would the subject matter of independent claims 2, 16, 19, 24, 25, and 26 have been obvious over Inoue in view of Okada?

More specifically, do Inoue and Okada disclose or suggest the teachings alleged in the Final Office Action? Is there any proper combination of Inoue and Okada that discloses or suggests <u>all</u> of the elements of at least the independent claims 2, 16, 19, 24, 25, and 26?

(8) Grouping of Claims

The claims stand or fall together.

(7) Argument

At a high level, Inoue is primarily concerned with techniques for combining a display unit with an image detector, in the manner(s) described therein. Even if Inoue references a CCD as being used as the image detector, Inoue does not disclose or suggest any particular aspect of a structure of such a CCD, beyond that which is standard in a construction of prior art CCDs, that relates to Applicant's recited CCD structure(s).

Somewhat similarly, even if Okada provides general teachings regarding a presence or absence of grain boundaries in a semiconductor device, with respect to certain charge mobilities, Okada does not disclose or properly suggest the features of Applicant's independent claims 2, 16, 19, 24, 25, and 26 that are alleged in the present Office Action, nor does Okada provide proper motivation to modify Inoue in the manner alleged in the present Office Action.

More specifically, and with respect to independent claim 2 for the sake of example, the Final Office Action of September 30, 2004 (which was supplemental to the (incomplete) Final Office Action of June 22, 2004) takes the following positions, enumerated and underlined below for clarity:

First, the Office Action asserts that Inoue teaches a semiconductor device "wherein at least one of the vertical and horizontal charge coupled devices comprises a crystalline semiconductor film having a plurality of crystals extending in a crystal growth direction..." (see Office Action, paragraph 3, lines 7-10).

In response, Appellant respectfully disagrees. Further, Appellant notes that the Office Action provides no reference to Inoue, or any portion thereof, that is thought to provide this teaching, other than a general reference to all of FIGS. 1-50.

Appellant's response of April 6, 2004 also noted the similar failure of the Office Action of January 6, 2004 to point with any particularity to this alleged teaching of Inoue. In response, the Office Action of September 30, 2004 stated in paragraphs 4-6 that, "Applicants contend that Inoue ... fails to disclose at least one of the vertical and horizontal charge coupled devices," and points to FIGS. 24 and 25 of Inoue, as well as to column 16, lines 39-54.

However, as noted in Appellant's response of January 7, 2005, this response of the September 30 Office Action mischaracterizes, and fails to respond to, Appellant's argument. That is, the Office Action incorrectly states the issue as whether Inoue discloses at least one of a vertical or horizontal CCD, and then responds by pointing to a portion of Inoue that merely states, "the photo-electric converter may be of the CCD-type."

In actuality, Appellant has clearly argued the issue of whether Inoue discloses or properly suggests that a (vertical or horizontal) CCD "comprises a crystalline semiconductor film having a plurality of crystals extending in a crystal growth direction." The Office Action is non-responsive on this point, and, moreover, the mention of a CCD-type photo-electric converter in

Inoue as a possible alternative to other image sensors described therein does nothing to illustrate any particular property of such a CCD, let alone the properties recited in claim 2.

Since Inoue does not disclose or properly suggest at least the claimed feature of a CCD having "a crystalline semiconductor film having a plurality of crystals extending in a crystal growth direction," and since neither Okada, nor any other reference of record, cures this deficiency, or is alleged to cure this deficiency, Appellant submits that claim 2 is allowable for at least this reason.

Second, and similarly, the Office Action asserts that Inoue teaches a semiconductor device "wherein a crystal structure of the crystalline semiconductor film 1753 in the crystal growth direction is continuous so that a charge moving is not restricted by a grain boundary …" (see Office Action, paragraph 3, lines 11-12).

Here, the Office Action appears to assert that film 1753 of FIG. 48 of Inoue discloses Appellant's claimed semiconductor film "having a plurality of crystals extending in a crystal growth direction… wherein a crystal structure of the crystalline semiconductor film in the crystal growth direction is continuous so that a charge moving is not restricted by a grain boundary."

However, film 1753 of Inoue appears to be mentioned just once in that reference, at column 27, lines 3-10, which states, "a substrate (FIG. 48) having an epitaxial layer formed on a silicone wafer…is used. This wafer is an SOI substrate having an epitaxial layer with even film thickness and good quality, which is obtained by etching the silicone substrate 1751 and porous silicone 1752 in a mixture silicon of HF and H.sub.2 O.sub.2 after bonding the epitaxial layer 1753."

There is no disclosure or suggestion of Inoue as to how these statements might apply to Appellant's claimed (charge-coupled) device, nor is there any disclosure or suggestion of Inoue as to how or why the film 1753 would have the recited properties. In particular, there is no discussion in Inoue of any grain boundaries, nor is there any reference to a crystal growth direction, much less a movement of charge with respect to these properties. Further, the Office Action does not provide any explanation or discussion on these points.

As above, then, since Inoue does not disclose or properly suggest at least the claimed feature of a CCD having "a crystal structure of the crystalline semiconductor film in the crystal growth direction is continuous so that a charge moving is not restricted by a grain boundary,"

and since neither Okada, nor any other reference of record, cures this deficiency, or is alleged to cure this deficiency, Appellant submits that claim 2 is allowable for at least this reason.

Third, the Office Action asserts that, although Inoue admittedly fails to teach "...a charge transfer direction of the at least one vertical and horizontal charge coupled devices is coincident with the crystal growth direction," that "Okada teaches that a crystalline semiconductor film is arranged such that a charge transfer direction of the at least one vertical and horizontal charge coupled devices is coincident with the crystal growth direction..." (see Office Action, paragraph 3, lines 13-18).

Okada, however, provides no teaching that is pertinent to the "charge-coupled devices" recited in claim 2. In particular, even assuming that Okada illustrates a (horizontal) crystal growth direction of a silicon grain and/or provides teachings concerning electron mobility with respect to a grain boundary, the Office Action makes no mention as to how either Inoue or Okada is thought to relate this crystal growth to (the arrangement of) the charge coupled device(s) recited in claim 2, such that the charge transfer direction of the charge coupled device(s) is coincident with the crystal growth direction.

In this regard, Okada contains only a limited mention of any CCD device, and then only as a light receiver for spectrochemical analysis, a function that is unrelated to the limitations of claim 2. Appellant recognizes that Okada may not be viewed or attacked as a single reference in the context of a combination of references under 35 U.S.C. 103(a); however, in the present case, Appellant submits that, as with Inoue, Okada does not provide the teaching(s) alleged in the Office Action.

That is, as referenced above, the Office Action maintains that Okada provides a teaching of a charge transfer direction of a charge coupled device (specifically, the Office Action states in lines 16-18 of paragraph 3 that "Okada teaches ...a charge transfer direction of the ... charge coupled device(s)..."), when, in fact, Okada provides no such teaching.

As above, then, since Okada does not disclose or properly suggest at least the claimed feature of a CCD having "at least one of the vertical and horizontal charge coupled devices that has the crystalline semiconductor film is arranged such that a charge transfer direction of the at least one of the vertical and horizontal charge coupled devices is coincident with the crystal growth direction," and since neither Inoue, nor any other reference of record, cures this

deficiency, or is alleged to cure this deficiency, Appellant submits that claim 2 is allowable for at least this reason.

Fourth and finally, the Office Action asserts that "...it would have been obvious to have the crystalline semiconductor film arranged such that a charge transfer direction of the at least one vertical and horizontal charge coupled devices is coincident with the crystal growth direction, because the mobility between the presence and absence of the grain boundary becomes more remarkable" (see Office Action, paragraph 3, lines 20-24).

Based on the above discussion, Appellant submits that an artisan of ordinary skill practicing Inoue (even to the extent that Inoue relates to standard, charge coupled devices) at the time of the invention would not have been motivated to look to Okada (which does not relate to charge coupled devices in any manner relevant to the subject matter of claim 2) to modify Inoue and obtain the subject matter of claim 2.

In conclusion, Appellant submits that the present Office Action fails to establish a primar facie case of obviousness under 35 U.S.C. 103(a). Specifically, Appellant submits that neither Inoue nor Okada, whether taken alone or in combination, discloses or properly suggests all of the elements of independent claim 2, so that claim 2 is believed to be allowable. As stated above, independent claims 16, 19, 24, 25, and 26 recite the same or similar features, and so are believed to be allowable for at least the same reasons, along with, for at least the same reasons, dependent claims 6, 11, 12, 14, 17, 18, and 20-23.

Accordingly, Appellant requests that the rejection of claims 2, 6, 11, 12, 14, and 16-26 be removed, and the present application passed to allowance.

The brief fee of $500 is enclosed. Please apply any other charges or credits to Deposit Account No. 06-1050.

Respectfully submitted,

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William G. Hughes, Jr.
Reg. No. 46,112

Fish & Richardson P.C.
1425 K Street, N.W.
11th Floor
Washington, DC 20005-3500
Telephone: (202) 783-5070
Facsimile: (202) 783-2331

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Appendix of Claims

Claim 1 (Canceled)

Claim 2: A semiconductor device comprising:

a plurality of photodiodes being formed in a matrix on an insulating surface;

a plurality of vertical charge coupled devices on the insulating surface, said vertical charge coupled devices being connected with the plurality of photodiodes;

at least a horizontal charge coupled device on the insulating surface, said horizontal charge coupled device being connected with the vertical charge coupled devices,

wherein at least one of the vertical and horizontal charge coupled devices comprises a crystalline semiconductor film having a plurality of crystals extending in a crystal growth direction,

wherein a crystal structure of the crystalline semiconductor film in the crystal growth direction is continuous so that a charge moving is not restricted by a grain boundary,

wherein at least one of the vertical and horizontal charge coupled devices that has the crystalline semiconductor film is arranged such that a charge transfer direction of the at least one of the vertical and horizontal charge coupled devices is coincident with the crystal growth direction.

Claims 3-5 (Canceled)

Claim 6: A device according to claim 2 further comprising an active matrix display device being integrated with said vertical and horizontal charge coupled devices over a same substrate.

Claims 7-10 (Withdrawn)

Claim 11: A device according to claim 2,

wherein the crystalline semiconductor film is formed over a quartz substrate, and

wherein an incident light is made from a side of the quartz substrate.

Claim 12: A device according to claim 2 wherein said charge transfer direction includes a plurality of directions.

Claim 13 (Canceled)

Claim 14: A device according to claim 2 wherein said semiconductor film is a silicon film.

Claim 15 (Withdrawn)

Claim 16: A semiconductor device including a CCD, said CCD comprising:

a crystalline semiconductor film formed on an insulating surface, said crystalline semiconductor film having a plurality of crystals extending in a crystal growth direction which is parallel to the insulating surface;

an insulating film on the crystalline semiconductor film;

a plurality of electrodes formed on the insulating film, each of said plurality of electrodes located within a predetermined distance so that a plurality of MOS capacitors are formed between the plurality of electrodes and the crystalline semiconductor film with the insulating film therebetween,

wherein a charge is transferred from one of the MOS capacitors to another of the MOS capacitors in a charge transfer direction,

wherein a crystal structure of the crystalline semiconductor film is continuous so that the crystal structure is regarded as single crystal for the charge,

wherein the charge transfer direction is coincident with said crystal growth direction.

Claim 17: A device according to claim 16, wherein said insulating surface is a quartz substrate.

Claim 18: A device according to claim 16, wherein said semiconductor device is at least one selected from the group consisting of an image sensor, a delay line, a filter, a memory and an operation unit.

Claim 19: A semiconductor device comprising:

a photoelectric conversion being formed over an insulating surface;

a charge coupled device being electrically connected to the photoelectric conversion device and formed over the insulating surface;

said charge coupled device including:

a crystalline semiconductor film being formed on the insulating surface, said crystalline semiconductor film having a plurality of crystals extending in a crystal growth direction which is parallel to the insulating surface;

an insulating film on the crystalline semiconductor film;

a plurality of electrodes being formed on the insulating film, each of said plurality of electrodes being located within a predetermined distance so that a plurality of MOS capacitors are formed between the plurality of electrodes and the crystalline semiconductor film with the insulating film therebetween,

wherein a charge is transferred from one of the MOS capacitors to another of the MOS capacitors in a charge transfer direction,

wherein a crystal structure of the crystalline semiconductor film in the crystal growth direction is continuous so that a charge moving is not restricted by a grain boundary,

wherein the charge transfer direction is coincident with the crystal growth direction.

Claim 20: A device according to claim 19, wherein said insulating surface is a quartz substrate.

Claim 21: A device according to claim 19, wherein said semiconductor device is an image sensor.

Claim 22: A device according to claim 19, wherein said photoelectric conversion device is a photodiode.

Claim 23: A device according to claim 19 further comprising an active matrix type liquid crystal display device being integrated over the insulating surface.

Claim 24: A semiconductor device comprising:

a plurality of photodiodes formed in a matrix on an insulating surface;

a plurality of vertical charge coupled devices on the insulating surface, said vertical charge coupled devices connected with the plurality of photodiodes;

at least a horizontal charge coupled device on the insulating surface, said horizontal charge coupled device connected with the vertical charge coupled device,

wherein at least one of the vertical and horizontal charge coupled devices comprises a crystalline semiconductor film having a plurality of crystals extending in a crystal growth direction,

wherein a charge transfer direction of at least one of the vertical and horizontal charge coupled devices is coincident with the crystal growth direction.

Claim 25: A semiconductor device comprising:

a photoelectric conversion formed over an insulating surface;

a charge coupled device electrically connected to the photoelectric conversion device and formed over the insulating surface;

said charge coupled device including:

a crystalline semiconductor film formed on the insulating surface, said crystalline semiconductor film having a plurality of crystals extending in a crystal growth direction which is parallel to the insulating surface;

an insulating film on the crystalline semiconductor film;

a plurality of electrodes formed on the insulating film, each of said plurality of electrodes located within a predetermined distance so that a plurality of MOS capacitors are formed

between the plurality of electrodes and the crystalline semiconductor film with the insulating film therebetween,

wherein a charge is transferred from one of the MOS capacitors to another of the MOS capacitors in a charge transfer direction,

wherein the charge transfer direction is coincident with the crystal growth direction.

Claim 26: A semiconductor device comprising:

a photoelectric conversion formed over a transparent substrate;

a charge coupled device electrically connected to the photoelectric conversion device and formed over the insulating surface;

said charge coupled device including:

a crystalline semiconductor film formed on the insulating surface, said crystalline semiconductor film having a plurality of crystals extending in a crystal growth direction which is parallel to the insulating surface;

an insulating film on the crystalline semiconductor film;

a plurality of electrodes formed on the insulating film, each of said plurality of electrodes located within a predetermined distance so that a plurality of MOS capacitors are formed between the plurality of electrodes and the crystalline semiconductor film with the insulating film therebetween, and

an active matrix display device comprising a plurality of thin film transistors formed over the transparent substrate;

wherein a charge is transferred from one of the MOS capacitors to another of the MOS capacitors in a charge transfer direction,

wherein the charge transfer direction is coincident with the crystal growth direction.